International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 4 Issue 10|| October 2015 || PP.01-12

A Methodological Framework to Estimate GHG from Travel Pattern of Tyne & Wear of Newcastle, UK with Various Policy Options using Fuzzy Logic Modal Split Model

Margaret Bell *,Pradip K Sarkar **,D.Dilum ***& Anil Namdeo ***

ABSTRACT:*An attempt has been made to study the existing travel pattern of NewcastleCity with a small of data set, UK. This would form a basis of appreciating the travel pattern with respect to mode of transport used, purpose, cost, frequency and length of travel according the different categories of socio-economic groups. In this paper, the existing travel pattern by the various socio-economiccategories of people were appreciated clearly in quantitative terms with the examination of the various transport related policy and strategy options to ascertain the degree of public transport to be developed for creating a conducive environment of better public transport travel condition by developing Modal Split model using Fuzzy Logic. The primary aim of the study was to explore ways and means with the help of transport policy options to quantify and reduce the green housegas emitted from the transport sector with the change modal split in favor of public transport. In order to demonstrate how to estimate the above gas from the travel pattern of Newcastle city, a small sample data of 248 commuters were collected in the year 2005 mostly traveling by car and public transport using bus and metro. Further an attempt has been made to study the travel characteristics for two types road users traveling by car and public transport. The approach demonstrated here would provide a basis for estimation of green house from the data collected from the transportation study conducted in 2005, 2011 and 2021.*

I. Background

Climate change resulting from the growing carbon foot print in the world is one of the burning issues threatening the survival of mankind. Transport sector is also responsible for generation of significant amount of green house gas of the order of 22 percent per annum (1) as compared to the other man made activities in the world. Apart from the emission of green house gas, there are a number of other air pollutants emitted from transport sector, also causing a great deal of problems to human health.

The SECURE (Self Energy Conserving Urban Environment) project through the approach of 4 M dealing with " Measurement, Modelling, Mapping and Management of air pollution data with a primary focus on estimation of carbon footprint, undertaken by the UK partners comprising of five academic universities has initiated to examine various issues of the emission of green house gas caused due to the large scale generation of human made activities in UK. The SECURE (2) project addresses the grand challenge of integrating greater conservation and more efficient resource utilisation across scales to meet future urban demands

It is increasingly felt that personalized mode of motorized vehicles is the cause of major pollutant, responsible to account for significant amount of not only in terms of the emission of green house gas but also responsible for generating other air pollutants, a serious concern for human health. It has led us to believe that the greater use of public transport can help bring down the green house gas. Therefore it is extremely important to assess the role of transport sector in relation to the generation of green house gas. In this context, an attempt has been made to study the existing travel pattern of Newcastle City with a small of data set, UK. Further analysis with a large set of data of 60,000 records of household would attempt to ascertain the characteristics of various parameters of travel of various socio-economic categories of people. This would form a basis of appreciating the travel pattern with respect to mode of transport used, purpose, cost, frequency and length of travel according the different categories of socio-economic groups.

Once the existing travel pattern by the various socio-economic categories of people are understood clearly in quantitative terms, then one can examine the various transport related policy and strategy options to ascertain the degree of public transport to be developed for creating a conducive environment of better public transport travel condition. Therefore a study of mode choice modeling would be an appropriate option in context of SECURE project. Finally one can quantify the magnitude of carbon emission with the detailed understanding of mode choice behavior of different categories of socio-economic groups of people not only for the present situation of travel characteristics but also help understand the quantum of generation of green house gas to be generated under different policy and strategy options in future.

In the light of the above, it is therefore necessary to systematically understand the stages of work associated in carrying out the above work. Presently, the data on travel and socio-economic are made available to a limited scale for the year 2005 for the city of Newcastle [3] . As described, the primary aim of the study would be to explore ways and means with the help of transport policy options to quantify and reduce the green house gas emitted from the transport sector with the change modal split in favor of public transport. In order to demonstrate how to estimate the above gas from the travel pattern of Newcastle city, a small sample data of 248 commuters were collected in the year 2005 mostly traveling by car and public transport using bus and metro. Further an attempt has been made to study the travel characteristics for two types road users traveling by car and public transport. The approach demonstrated here would provide a basis for estimation of green house from the data collected from the transportation study conducted in 2005, 2009 and 2010.

1 Study Area Profile

1.1 Socio-Economic

Tyne and Wear of Newcastle located in the north east of England with an area of 55,000 hector (4) comprises of New castle Upon Tyne, Sunderland, Gateshead, North Tyne side and South Tyne Side. As per census of 2001, it has registered more than 1.6 million population surrounded by Northumberland and Durham and is forecast for further growth of 6 percent in the nest 25 years. This area has grown strongly from a strong economic base on coal mining and ship building. This area is bestowed upon 40 percent of green space – an important indicator for ecological balance.

1.2 Transport System

Over a period of time, Tyne and Wear of Newcastle has emerged to have developed a balanced transport system emphasizing with both road network system and public transport system equally supported with strong metro and public transport operation covering almost all the areas of Tyne and Wear.. Metro as shown in Fig 1 has grown considerably to a height by carrying as many as 40 million passengers since 2006.

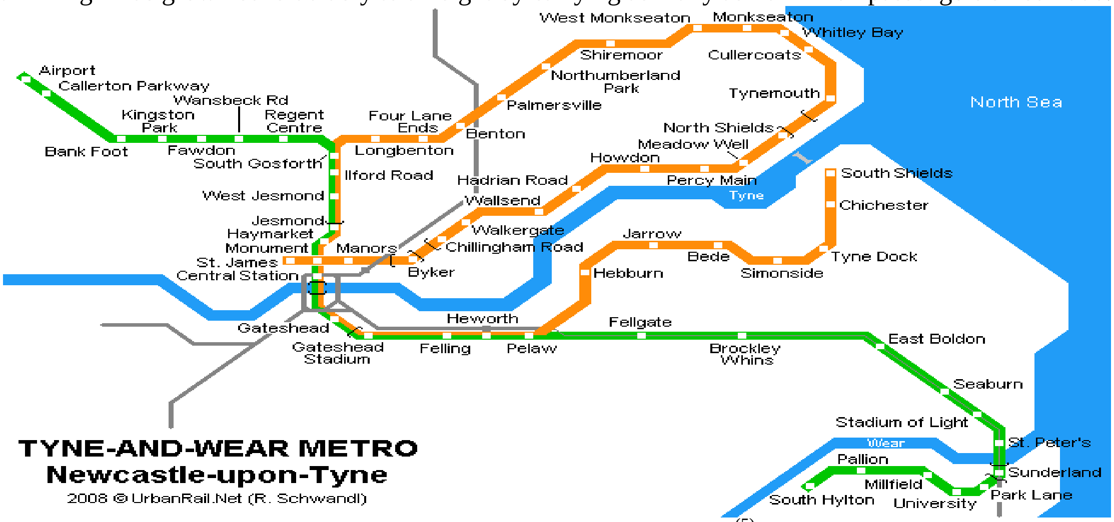

Fig1 Map showing the Metro Network in Newcastle Upon Tyne[5]

1.3 Travel Pattern

Due to good road network and likely increase in car ownership from 57 percent in 2006 to 73 percent reported to reach in 2031, the car trips are expected to grow to 20 percent in 2031 resulting in the overall increase of 6.1 percent of person trips on the road network. The average trip length of car and public transport in Tyne and Wear would increase to 11.6 percent and 5.9 percent respectively.

2 Methodology

In order to accomplish the objectives, it is essential to develop a sound methodology, which can be the basis for the estimation of green house gas in particular. Presently, the data on travel and socio-economic are made available for the past year 2005, 2009 and 2010 for the Tyne and Wear of Newcastle. As described earlier, the primary aim of the study would be to explore ways and means with the help of transport policy options to quantify GHG with view to determining the extent of reduction of greenhouse gas to be emitted from the transport sector due to change the change of modal split in favor of public transport. Keeping this in view, an attempt is made to present a methodological framework for various stages of work as presented below.

2.1 Stage I: Appreciation of Data Input

- Scrutiny of Tyne and Wear of Newcastle's socio-economic and travel data pertaining to around 60,000 data records collected for a period of number of years.
- Formatting and arrangement of the required data set for analysis
- Identification of parameter of data to be used for analysis.

2.2 Stage II: Preparation of Data Set according the Various Categories of Socio-Economic Groups

- The following Categories Data are identified.
  Four categories of classifications for category analysis for studying the travel behavior of various categories of people are considered for the study. These are namely:
  1) Status: employed, student, unemployed
  2) Car ownership: without any car, with one car, with two or more car
  3) gender: male or female
  4)Age group: 5-24year , 25-45 year , 46-60 year , above 60 year

Therefore there will be around 72 categories of households to be dealt with for more than 15, 000 household data to be analyzed from the year 2005 to 2010 . The data for each year is required to be prepared for comparative analysis so to examine any change of travel behavior of people over a period of time.
Once the above inputs are prepared into data base with respect to specific year, then categories will be prepared using the filtering process.

2.3 Stage III: An Analysis of Travel Behavior of Various Categories of Household Travel Data

In the first instance, an attempt will be made to analyze the travel characteristics of different categories of people as outlined above. These include the following such as
i) analyses of trip rate of different categories of people with respect to total trip generation rate, ii) trip generation rate according to modes of travel, iii) trip length by mode and purpose, iv)measure of utility for different modes of travel by various categories of people etc. Each category of data set is to be analyzed with respect to different years to appreciate any change of travel behavior of people over a period of time.

2.4 Stage V: Approach to Mode choice Modeling using Fuzzy Logic Technique

Mode choice behavior models the traveler choice of mode of transport to be selected for his or her travel , e.g. car, bus, Rail etc. Major interest in mode choice modeling is to predict the decision making behavior of a group of individuals. The further interest is to determine the relative influence of various attributes of alternatives and characteristics of decision makers when they make choice decisions.
Mode Choice Modeling will be carried using Fuzzy Logic utility model where various utilities in the form of membership functions [(6,7)] can be developed.
Fuzzy logic utility model is developed in which functions of fuzzy logic is demonstrated along with different membership functions of parameters. If-Then rules are formulated to finally get final utilities of travel for different modes of transport. Fuzzy utility method will be developed through Matlab software. The output here will be directly observed in the form of choice of modes.

2.5 Stage V: Mathematical Framework

It is important to summarize the mathematical framework for application of fuzzy logic for mode choice modeling as presented here.
Consider a multi-input, multi-output system. Let x = (x1, x2,...xn)T be the input vector and
y = (y1,y2,...ym)T be the output vector. The linguistic variable xi in the universe of discourse U is characterized by :

$$T(x) = \{T_x^1, T_x^2, T_x^3, \ldots T_x^k\} \text{ and } \mu(x) = \{\mu_x^1, \mu_x^2, \mu_x^3, \ldots \mu_x^k\}$$

whereT(x) is a term set of x; that is set of names of linguistic values of x, with each being a fuzzy member and the membership function defined on U. As an illustration, we consider a fuzzy inference system with two inputs and one output. Let the two inputs represent the Travel cost & Comfort level in mode, and let the output of the system be Utility of mode. Let x1 indicate the Travel cost, represent its term set {Very small, Small, Medium, Big, Very big}, and the universe of discourse be [5-50] . Let x2 indicate the comfort level in mode, the universe of discourse be [0-100], and the corresponding term set be {Very low, low, average, high, Very high}. Similarly, linguistic variable y in the universe of discourse V is characterized by (y)={T_y^1, T_y^2, T_y^3… T_y^k}, where T(y) is a term set of y; that is, T is the set of names of linguistic values of y, with each T_y^ibeing a fuzzy membership function u_y^i defined on V. as shown in Figure 1.
If the variable y represents Utility of mode, then represents a term set {very low, low, medium, high, very high}, and the universe of discourse is [0–2], which represents the minimum and maximum as, '0', and '2', respectively.

In order to map input variables with their membership functions of x1 and x2 to output y, it is necessary that we first define the corresponding fuzzy sets. The input and output variables with their membership functions are shown in Fig 2 The first step in evaluating the output of a FIS(Fuzzy Inference System) is to apply the inputs and determine the degree to which they belong to each of the fuzzy sets. The fuzzifier block performs the mapping from the input feature space to fuzzy sets in a certain universe of discourse. A specific value x1 is then mapped to the fuzzy set with degree of membership and so on. In order to perform this mapping, we can use fuzzy sets of any shape, such as triangular, Gaussian, π-shaped, etc.

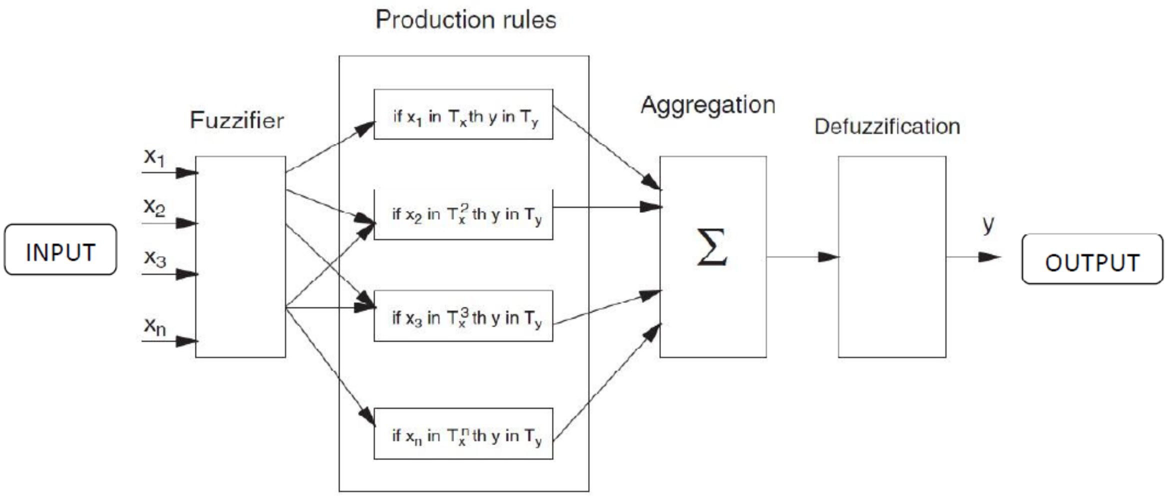

Figure 2 Input and Output Variables :Fuzzy Inference System

The complete process of developing the shape of traingular membership function for variables like overal travel time, invehicle travel time, travel cost and comfort [(7)] was shown in Fig 3.

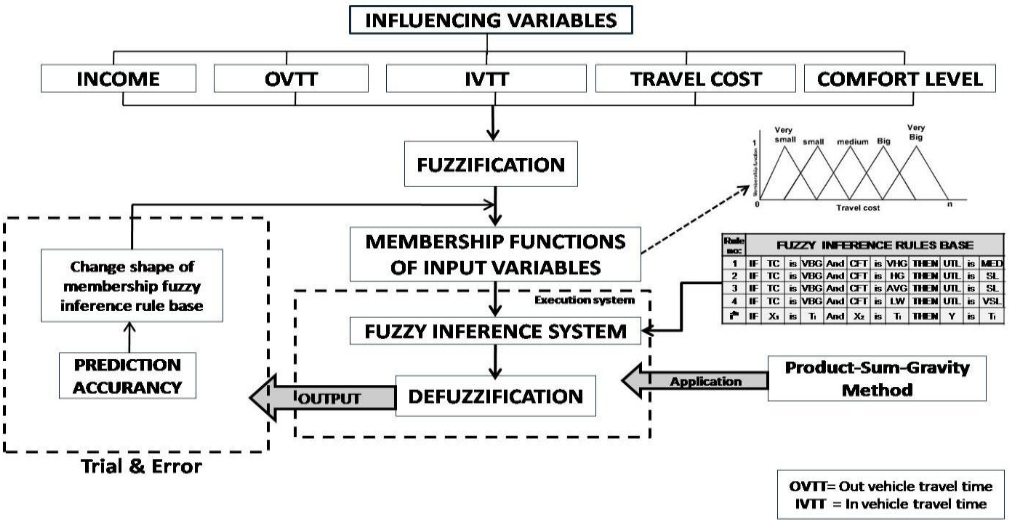

Figure3 Complete Process for developing Fuzzy Logic Model with Triangular Membership along with rule base .

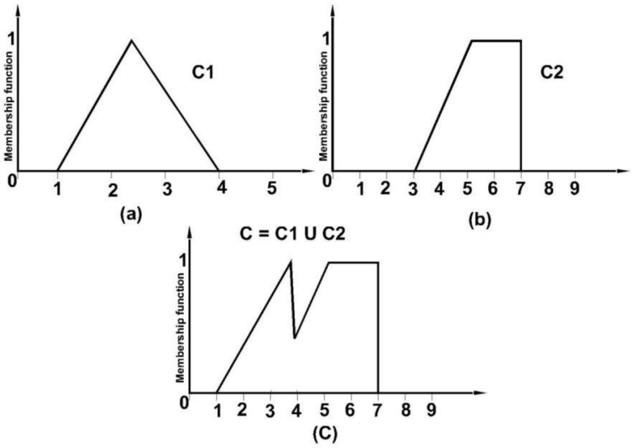

Figure 4 Membership Functions for Input and Output variables

Conversion of input membership functions to output membership function is shown in **Fig 4 .**Defuzzyfication is carried out in the next step. Defuzzyficaion means the fuzzy to crisp conversions. This can be achieved by using defuzzyfication process. The defuzzyfication has the capability to reduce a fuzzy to a crisp single-valued quantity. Defuzzyfication can also be called as "rounding off" method. A fuzzy inference system maps an input vector to a crisp output value. A crisp output, results from defuzzyfication process. The most commonly used method is the Centroid. Other methods include the maximum, the means of maxima, height, and modified height method. Apart from the lambda cut sets and relations which convert fuzzy sets or relations into crisp sets or relations, there are other various defuzzyfication methods employed to convert the fuzzy quantities into crisp quantities. The output of an entire fuzzy process can be union of two or more fuzzy membership functions as shown in **Fig 5.**

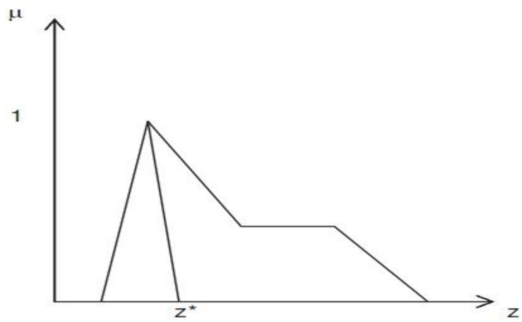

Figure 5 Typical Fuzzy Output

2.6 StageVI. Development of Mode of Choice Model using Fuzzy Logic

There are a number of modeling techniques available to construct mode choice behavior model. These include Multinomial Logit Model, Artificial Neural Network and Fuzzy Logic technique. It has been observed from the various studies on mode choice behavior that Fuzzy Logic(1,2,3,4) appears to be the most reliable method for correctly assessing mode choice behavior as compared to other techniques. In view of this , it was decided to develop the mode choice modeling using Fuzzy logic technique. While developing Fuzzy Logic, there are three ways, one can attempt to construct the model. These are namely i) Fuzzy Manual Rule Base Model , ii) Fuzzy Subtractive Clustering Model iii) Fuzzy FCM . While developing this model, the data are required to be segregated into two parts known as training and testing data. Therefore Fuzzy Logic Model is to be developed initially using the training data and finally validation will be carried out with the testing data. The most important part is to assess the degree of accuracy of the model through the following steps.

i) Development of model with training data
ii) Validation of model with testing data
iii) Accuracy of the model

Among the three methods described above, the reliable method for highest level of accuracy is the Fuzzy C means Clustering which has been considered in this study

2.7 Stage VII. Policy Analysis Using Fuzzy Logic

At this stage of work, a number of transport policies and strategies can be tested to examine the change in modal split in favour of public transport system. These may include i) increase in the operation of cost fuel for personalized vehicles ii) lowering the fare of public transport iii) improvement in the accessibility of with respect to operation of public transport system, effect of congestion pricing on the shift of choice riders to public transport system etc. In order to carry out policy sensitive study , the following strategies as a part of increase in fuel price policy and promotion of public transport system with respect to reduction of public transport fare are considered to test the extent of reduction of trips with respect to personalized vehicles. Therefore the following strategies are considered appropriate to test the above policies.

1. The increase in 10 percent of fuel cost for personalized vehicles
2. The increase in 20 percent of fuel cost for personalized vehicles
3. The increase in 30 percent of fuel cost for personalized vehicles
4. The increase in 40 percent of fuel cost for personalized vehicles
5. The increase in 50 percent of fuel cost for personalized vehicles
6. The decrease in 10 percent of public transport fare
7. The decrease in 20 percent of public transport fare
8. The decrease in 30 percent of public transport fare
9. The decrease in 40 percent of public transport fare
10. The decrease in 50 percent of public transport fare
11. The combination of both in terms of 10 % increase in fuel cost and 10 % decrease in public transport fare
12. The combination of both in terms of 20 % increase in fuel cost and 20 % decrease in public transport fare
13. The combination of both in terms of 30 % increase in fuel cost and 30 % decrease in public transport fare
14. The combination of both in terms of 40 % increase in fuel cost and 40 % decrease in public transport fare
15. The combination of both in terms of 50 % increase in fuel cost and 50 % decrease in public transport fare

A more number of combinations can be made as desired by the policy makers in order to arrive at a appropriate decision.

2.8 Stage VIII Results under Various Policy Options

In this stage of work, the outcome of results from the above policy options based on the small sample data have been summarized for comparison in order to appreciate the importance and relevance of various policy options. This will enable decision-makers to take appropriate decision in favour of ensuring sustainable transport system.

2.9 Stage IX Estimates of Green House Gas and Other Air Pollutants at City Level:

In this stage, the data on vehicle-km of travel to be estimated from the mode choice modeling will be used for estimation of green house gas after duly considering standard vehicle emission factors with respect to vehicle km travel by personalized vehicles and public transport. For the purpose of estimation of GHG , travel demand estimate for base year and future year is required. The above estimate for travel demand with respect to passenger trips for car and public transport for the year 2001 , 2011 and 2021 has been made by the Local Transport Plan for Tyne and Wear [(8)]prepared for 2006-2011 as presented below.

Table 1 Travel Demand Estimates for Car and Public Transport(Bus& Metro) within and Outside Urban Centres in 2001, 2011 and 2021

	Mode	Year 2001	Year 2011	Year 2021
To Urban Centres	Public Transport	129,558	133,772	138,676
To Urban Centres	Car	196,032	197,753	208,017
To Urban Centres	Total Trips	325,590	331,525	346,693
To Other Outside Destinations	Public Transport	245,412	238,463	202,283
To other Outside Destinations	Car	1,240,259	1,368,308	1,442,163
To Other Outside Destinations	Total Trips	1,485,671	1,606,771	1,644,446
Total Trips in Tyne and Wear		1,811,262	1,938,295	1,991,140

Source: Local Transport Plan, Tyne and wear, 2006-2011(Ref No 1)

As public transport system comprises of bus and metro within the urban area, its composition between bus and metro is 78.5 percent and 21.5 percent respectively as per annual bus and metro boarding in 2004 (Ref 8). Therefore the total trips performed by the public transport system with the urban area can be proportioned to the above composition in order to approximately estimate the GHS for the buses. The above Table is converted to vehicular trips by taking into account of occupancy factors for car and bus of 1.2 and 19.5 respectively. Table 2 presents the passenger trips with respect to car and bus by considering the above share of trips to be performed by bus passengers.

Table 2 Total Numbers of Car and Bus Passenger Trips in 2011 and 2021

	Mode	Year 2001	Year 2011	Year 2021
To Urban Centres	Bus Passenger	101,703	105,011	108,861
To Urban Centres	Car Passenger	196,032	197,753	208,017
To Urban Centres	Total Trips	297,735	302,764	316,878
To Other Outside Destinations	Bus Passenger	192,648	187,193	158,792
To other Outside Destinations	Car Passenger	1,240,259	1,368,308	1,442,163
To Other Outside Destinations	Total Trips	1,432,907	1,555,501	1,600,955
Total Trips		1,730,642	1,858,265	1,917,833

Table3 presents the total number of trips made by bus and car in 2011 and 2021.

Table 3 Total Numbers of Car and Bus Trips in 2011 and 2021

	Mode	Year 2001	Year 2011	Year 2021
To Urban Centres	Bus Trips	5,385	5,583	5,583
To Urban Centres	Car Trips	163,360	164,794	173,348
To Urban Centres	Total Trips	168,745	170,377	178,930
To Other Outside Destinations	Bus Trips	9,879	9,600	8,143
To other Outside Destinations	Car Trips	1,033,549	1,140,257	1,201,803
To Other Outside Destinations	Total Trips	1,043,429	1,149,856	1,209,946
Total Trips in Tyne and Wear		1,212,174	1,320,233	1,388,876

In order to estimate the green house gas, the total vehicular trips made both by car and bus traffic is converted into vehicle-Km of travel after multiplying with their respective average trip length of 11.2 km and 4.7 km for the year 2011. Similarly for the year 2021, the average trip length of 11.8 km and 4.5 km was used as per the estimate of the Local Transport Plan, Tyne and Wear. Table 4 presents the vehicle km travel by bus and car for 2011and 2021.

Table 4 Total Vehicle Km travelled by Car and Bus Trips in 2011 and 2021

	Mode	Year 2011	Year 2021
To Urban Centres	Bus (Veh Km)	26238	26238
To Urban Centres	Car (veh Km)	1845695	1941492
To Urban Centres	Total Trips	1871933	1967730
To Other Outside Destinations	Bus (Veh Km)	45118	38273
To other Outside Destinations	Car (veh Km)	12770875	13460188
To Other Outside Destinations	Total Trips	12815993	13498461
Total Trips in Tyne and Wear		14.687926million	15.466191million

III. Estimation of Green House Gas using Sample Data of Newcastle City

Based on the above methodology, an attempt has be made to use a sample data on travel of the Newcastle city collected during the period of 2005(Naveed). As the data size is small with 248 records dealing with variables of travel time , travel cost , income of households together with the transport mode used for the journey to work, transport modes namely bus and metro were considered under public transport system. Though it happens to be a representative data collected from the various part of the city, the data was found sensitive according to its travel and economic attributes selected for the use of model. As described earlier, this modeling exercise is an attempt being used as a demonstrative example to estimate the modal split under different policy scenarios. This can be used as major input to estimate greenhouse gas. Similar exercise could be applied on a large scale data for Tyne and Wear of Newcastle as recorder over different period of time to get a correct estimate of GHG. Before attempting to estimate greenhouse gas for various policy options, an effort was made to estimate the quantum of greenhouse gas for travel demand estimated for 2011 and 2021 as presented in the Table 5.

Table 5 Estimation of Greenhouse Gas for 2011 and 2021

	Mode	Year 2011	Year 2021
To Urban Centres	Bus (Veh Km)	17976690016	17976690016
To Urban Centres	Car (veh Km)	3.07875E+11	3.23855E+11
To Urban Centres	Total Trips	3.25852E+11	3.41831E+11
To Other Outside Destinations	Bus (Veh Km)	28345039829	24044483596
To other Outside Destinations	Car (veh Km)	2.04863E+12	2.15921E+12
To Other Outside Destinations	Total Trips	2.07698E+12	2.18325E+12
Total Trips in Tyne and Wear		2.40283E+12	2.52508E+12

The above analysis reveals that the total green house for 2011 and 2021 is of the order of 2.40283 MT and 2.52508 MT per day respectively according to estimated travel demand in 2011 and 2021.

3 Analysis of Sample Data for Mode Choice Model and Estimation of GHG under Different Policy Options of Tyne of Newcastle City

3.1 Travel Characteristics

Overall travel time recorded as a part of data was analyzed with respect to distribution of trip length in terms of travel time and travel cost. Average overall travel time estimated to be 33 minute and 38 minute with respect to car and bus respectively as is found to be higher than average in-vehicle travel time by car and bus reported by the Local Transport Plan carried out for 2006 and 2011 which was11 minute and 14 minute respectively which does not include time on walking , waiting, time from parking to destination. The distribution of travel time and travel cost are shown in Fig 6 and Fig 7 respectively. Similarly distribution of travel cost of car and public Transport is shown in Fig 8 and Fig 9 Travel cost of car is found to be higher primarily due to the inclusion of parking charges at the destination end.

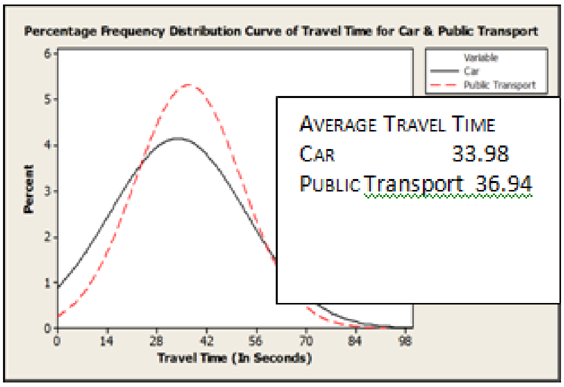

Figure 6Distribution of Travel Time

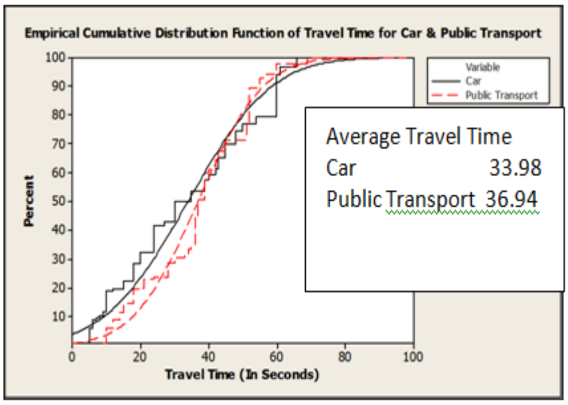

Figure 7 Cumulative Distribution of Travel Time

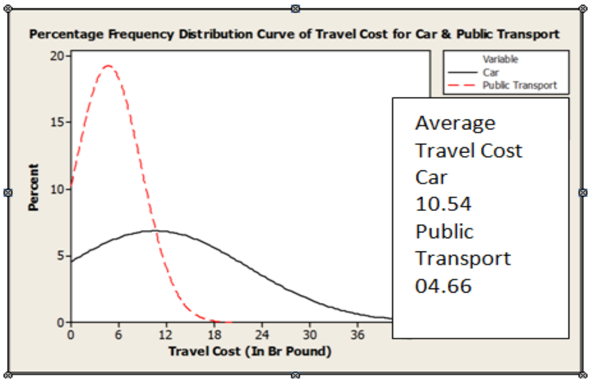

Figure 8 Distribution of Travel Cost

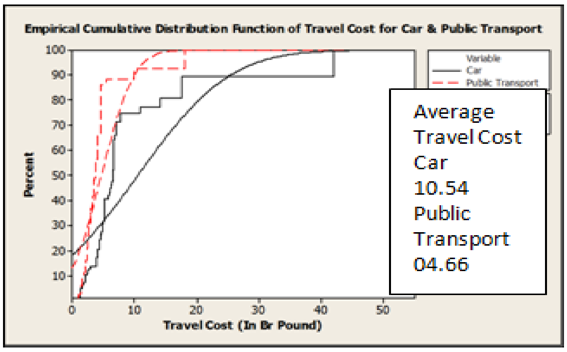

Figure 9 Cumulative Distribution of Travel Cost

3.2 Mode Choice Modeling Using Fuzzy Logic.

Matlab software was used to develop the Fuzzy Logic Model based on C-Mean Approach where defuzzification of membership values was created by Mamdani rule. Initially, out of 248 data set, 147 data set was used for training purpose while 81 was considered for testing purpose. After running the model with the input data, the output of the model generated in terms car and public transport as the model output was tested with the original data prepared from the travel survey data for the purpose of calibration. It can be seen from the Table 6 that the fuzzy model predicts an accuracy of 74.80 percent

Table 6 Results of Mode of Model using training data

Results	Number of Samples		Accuracy (percent)
total true	110		
total false	37		
Accuracy=	(110/147)x100	=	74.80%

Fig 10shows the membership functions with respect to travel time , travel cost of travelers.

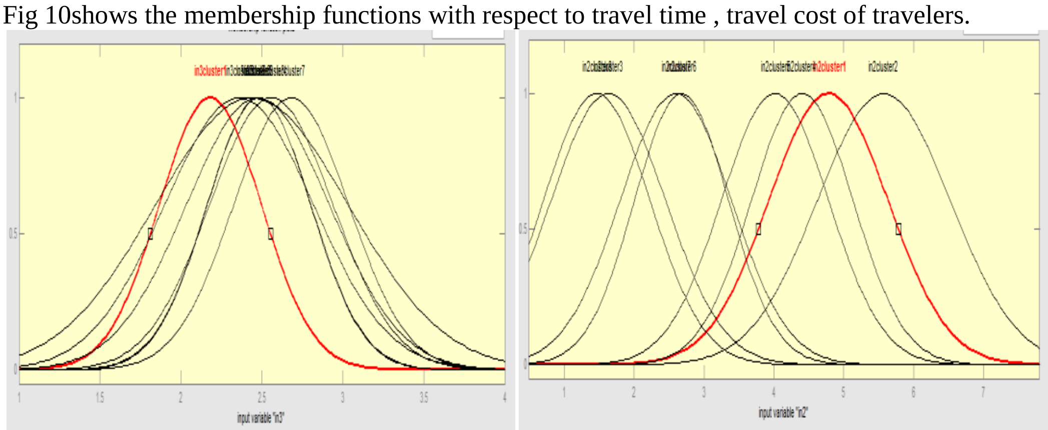

Figure 10 Membership Function of Travel Time Membership Function of Travel Cost

Finally, taking the remaining part of the data set was used for validation of the model to ensure that model can be accepted for prediction of mode choice. It is noteworthy to mention that higher degree of accuracy was observed to the extent of 78.75 percent as presented in the Table 7.

Table 7 Validation of Mode Choice Model using Testing Data

TRUE	63	
FALSE	18	
Accuracy	78.75	%

3.3 Policy Options to Estimate the Shift in Trips from Personalized Vehicles to Public Transport

As described above, the above fifteen policies have been tested and their results are summarized in the table given below.

Table 8 Effects of Policy Options on Car and Public Transport Passenger trips

S.No	Policy Options	Shift from PV to PT in %	Shift from PT to PV in %	Effect of Change
1	The increase in 10 percent of fuel cost for personalized vehicles	0.66	No shift	PV trips decreased.
2	The increase in 20 percent of fuel cost for personalized vehicles	2.66	No shift	PV trips decreased.
3	The increase in 30 percent of fuel cost for personalized vehicles	3.33	No shift	PV trips decreased.
4	The increase in 40 percent of fuel cost for personalized vehicles	5.33	No shift	PV trips decreased.
5	The increase in 50 percent of fuel cost for personalized vehicles	8.66	No shift	PV trips decreased.
6	The decrease in 10 percent of public transport fare The decrease in 10 percent of public transport fare	No shift	No shift	No shift
7	The decrease in 20 percent of public transport fare	No shift	No shift	No shift
8	The decrease in 30 percent of public transport fare	0.6	No shift	PV trips decreased
9	The decrease in 40 percent of public transport fare	1.33	No Shift	PV trips decreased
10	The decrease in 50 percent of public transport fare	2	No shift	PV trips decreased
11	The combination of both in terms of 10 % increase in fuel cost and 10 % decrease in public transport fare	0.66	No shift	PV trips decreased
12	The combination of both in terms of 20 % increase in fuel cost and 20 % decrease in public transport fare	2.66	No shift	PV trips decreased
13	The combination of both in terms of 30 % increase in fuel cost and 30 % decrease in public transport fare	4	No shift	PV trips decreased
14	The combination of both in terms of 40 % increase in fuel cost and 40 % decrease in public transport fare	6.67	No shift	PV trips decreased
15	The combination of both in terms of 50 % increase in fuel cost and 50 % decrease in public transport fare	10.66	No shift	PV trips decreased

It can be seen from the above Table that there is a shift of 0.6 percent from personalized vehicles to public transport even with an increase of 10 percent of increase in price of fuel cost of personalized vehicles and then gradually shift is taken place from 0.6 percent to 2.66 percent at 20 percent increase in cost fuel price. Finally, the increase in shift of commuters from car to public transport from 20 percent of increase in price of fuel cost to 50 percent increase in price of the fuel cost exhibits a change in shift from 2.66 percent to 10.66 percent.

3.4 Estimation of GHG under Various Policy Options

In order to estimate the magnitude of GHG as well as its change with respect to base year travel demand of 2011, an attempt has been made to estimate emission of GHG under various policy options by considering prevailing vehicular emission standards in context of UK as presented in Table 9. The average speed of vehicular stream in urban centres and outside other destination in Tyne and Wear as 30 mph and 50 mph was referred.. The combined effect of 50 percent change by considering a decrease in public transport cost together with increase in fuel price for personalized vehicles exhibits a maximum reduction of more than 9 percent in GHG.

Table 9 Estimates of GHG under Policy Options

S.No	Policy Options	Shift to PT	Effect of Change	Emission of GHG		Change in GHG Emission in (%)	Change in GHG Emission in (%)
				2011	2021	2011	2021
0				2.4	2.52		
1	Policy 1	0.66	Decrease in PV Trips	2.39	2.51	-2.083	-1.984
2	Policy 2	2.66	Decrease in PV Trips	2.35	2.47	-2.917	-2.778
3	Policy 3	3.33	Decrease in PV Trips	2.33	2.45	-2.917	-2.778
4	Policy 4	5.33	Decrease in PV Trips	2.29	2.4	-4.583	-4.762
5	Policy 5	8.66	Decrease in PV Trips	2.22	2.3	-7.500	-8.730
6	Policy 6	No Shift	No Shift	2.4	2.52	0.000	0.000
7	Policy 7	No shift	No Shift	2.4	2.52	0.000	0.000
8	Policy 8	0.6	Decrease in PV Trips	2.39	2.51	-0.417	-0.397
9	Policy 9	1.33	Decrease in PV Trips	2.37	2.5	-1.250	-0.794
10	Policy 10	2	Decrease in PV Trips	2.35	2.47	-2.083	-1.984
11	Policy 11	0.66	Decrease in PV Trips	2.4	2.52	0.000	0.000
12	Policy 12	2.66	Decrease in PV Trips	2.35	2.47	-2.083	-1.984
13	Policy 13	4	Decrease in PV Trips	2.32	2.43	-3.333	-3.571
14	Policy 14	6.7	Decrease in PV Trips	2.22	2.33	-7.500	-7.540
15	Policy 15	10.66	Decrease in PV Trips	2.18	2.29	-9.167	-9.127

IV. Conclusions

The study developed as a methodological framework is primarily designed to examine the reduction of GHG using a number of transport policy options and is a demonstration, which explains the methodological framework to be considered for analysis of a comprehensive data set of 60,000 households travel records. The methodology demonstrated in this report aims at for analyzing various aspects of travel characteristic with respect to trip length , purpose of trips, along with mode choice behavior for selected socio-economic groups of people . There are 72 categories of socio-economic groups identified to be taken up for detailed study. Most important part of the analysis is the study of mode choice model using the technique of Fuzzy logic which is the central theme for examining the reduction of greenhouse gas . C-Mean- Clustering, one of the popular techniques in the Fuzzy Logic Model has been applied to demonstrate mode choice behavior of commuters with a sample data size of 248. Fuzzy Utility based model in terms of membership functions was developed with an accuracy of more than 75 percent through its calibration and validation process. In order to appreciate mode choice behavior of commuters, fuzzy logic model developed was tested under as many as fifteen policy options. The modal shift in favour of public transport which was estimated from a set of sample data was used to for a total travel demand (ref 7) for city under the fifteen policy options. It is estimated that there is a shift of trips from car to public transport from mere 0.66 percent of total trips under policy 1 and keeps increasing with harsher policy in context of car users. Maximum shift of trips from car users of the order of 10.66 percent of the total trips in favour of public transport is estimated under the policy option 15 . The results derived from the above policies with respect shift of trips of car to public transport was applied on an estimated travel demand for 2011 and 2021 of Tyne and Wear of Newcastle through a number of stages of analysis to estimate the reduction of greenhouse gas. It is seen from the analysis that the magnitude of emission of greenhouse gas for 2011 and 2021 at D0-Nothing scenario is of the order of 2.4MT and 2.52 MT per day. It is worth mentioning that fifteenth policy options as explained above would help reduce the emission of greenhouse gas to maximum extent of 9.127 percent in 2021 as against the Do-Nothing situation.

References

[1] Sikdar, P.K. (2003). Presentation on "Climate Change its Implication in India Brainstorming Session" NEERI Nagpur.

[2] https://www.secure-project.org/

[3] Naveed, M.A, " Travel demand Modelling Considering; The Case Study of Newcastle", Unpublished dissertation, M.Sc. in Transportation Engineering & Operations, TORG, School of Civil Engineering, Newcastle University, September,2005

[4] EPSRC" SOLUTIONS, Sustainability of land use and Transport inNeighbourhood, Final Report, November,2010

[5] https://www.google.co.in/search?q=newcastle+upon+tyne+metro+system+map&client=firefox-a&rls=org.mozilla:en-US:official&channel=np&tbm=isch&tbo=u&source=univ&sa=X&ei=xnzvU4UD1ufwBbrUgtAB&ved=0CDcQsAQ&biw=1241&bih=691

[6] Rajsekharan,S&VijayLakshmiPai .G.A" Neural Networks, Fuzzy Logic, and Genetic Algorithm",PHIPvt Ltd,2003

[7] Kathuria, A "Intercity Mode Choice Modelling Using Soft Computing", Unpublished Thesis, Master of Transport Planning, School of Planning and Architecture, New Delhi , 2013

[8] Local Transport Plan, Tyne and Wear, 2006-2011.